

Biosafety Levels

Biosafety levels (BSL) are used to identify the protective measures needed in a laboratory setting to protect workers, the environment, and the public. The levels are defined in [Biosafety in Biomedical Laboratories \(the BMBL\)](#). Biosafety level designations in the BMBL outline specific practices and safety and facility requirements. There are many ways to combine equipment, practices, and laboratory design features to achieve appropriate biosafety and biocontainment. These are determined through biological risk assessments specifically conducted for each experimental protocol.

[Risk assessments](#) are conducted by evaluating the way in which the infectious agents or toxin is transmitted and its ability to cause disease, the activities performed in the laboratory, the safety equipment and design elements present in the laboratory, the availability of preventive medical countermeasures or treatment, and the health and training of the laboratory worker. For example, some procedures with an infectious agent or toxin may be conducted under BSL-2 conditions, but other procedures with the same infectious agent or toxin that increase the risk to the worker or environment, such as the creation of airborne droplets or sprays, or large scale production, may require that the work be conducted under BSL-3 conditions.

At any given biosafety level, there will be strict requirements for [laboratory design](#), [personal protective equipment](#), and [biosafety equipment](#) to be used. [Standard Microbiological Practices](#) are required at all biosafety levels and are good practice for experiments below the BSL-1 threshold.

Activities and projects conducted in biological laboratories are categorized by biosafety level. The four biosafety levels are BSL-1, BSL-2, BSL-3, and BSL-4, with BSL-4 being the highest (maximum) level of containment. There are additional specific rules and designations for animal research (ABSL), agricultural research (BSL-Ag), and other types of research. These other types of labs require their own specific set of rules and regulations, because they are dealing with larger organisms, such as plants, animals, and insects.

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Biosafety Level 1 (BSL-1)

BSL-1 labs are used to study infectious agents or toxins not known to consistently cause disease in healthy adults. They follow basic safety procedures, called [Standard Microbiological Practices](#) and require no special equipment or design features. Standard engineering controls in BSL-1 laboratories include easily cleaned surfaces that are able to withstand the basic chemicals used in the laboratory.

Biosafety Level 2 (BSL-2)

BSL-2 laboratories are used to study moderate-risk infectious agents or toxins that pose a risk if accidentally inhaled, swallowed, or exposed to the skin. Design requirements for BSL-2 laboratories include hand washing sinks, eye washing stations in case of accidents, and doors that close automatically and lock. BSL-2 labs must also have access to equipment that can decontaminate laboratory waste, including an incinerator, an autoclave, and/or another method, depending on the biological risk assessment.

Biosafety Level 3 (BSL-3)

BSL-3 laboratories are used to study infectious agents or toxins that may be transmitted through the air and cause potentially lethal infection through inhalation exposure. Researchers perform all experiments in [biosafety cabinets](#) that use carefully controlled air flow or sealed enclosures to prevent infection. BSL-3 laboratories are designed to be easily decontaminated. These laboratories must use controlled, or “directional,” air flow to ensure that air flows from non-laboratory areas (such as the hallway) into laboratory areas as an additional safety measure.

Other engineered safety features include the use of two self-closing, or interlocked, doors, sealed windows and wall surfaces, and filtered ventilation systems. BSL-3 labs must also have access to equipment that can decontaminate laboratory waste, including an incinerator, an autoclave, and/or another method, depending on the biological risk assessment.

Biosafety Level 4 (BSL-4)

BSL-4 laboratories are used to study infectious agents or toxins that pose a high risk of aerosol-transmitted laboratory infections and life-threatening disease for which no vaccine or therapy is available. The laboratories incorporate all BSL 3 features and occupy safe, isolated zones within a larger building or may be housed in a separate, dedicated building. Access to BSL-4 laboratories is carefully controlled and requires significant training.

There are two types of BSL-4 laboratories:

- Cabinet laboratory – all work with infectious agents or toxins is done in a Class III [Biosafety Cabinet](#) with very carefully designed procedures to contain any potential contamination. In addition, the laboratory space is designed to also prevent contamination of other spaces.

- Suit laboratory – Laboratory personnel are required to wear full-body, air-supplied suits, which are the most sophisticated type of [personal protective equipment](#). All personnel shower before exiting the laboratory and go through a series of procedures designed to fully decontaminate them before leaving.

The engineering controls required are different for BSL-4 cabinet and suit laboratories. For either type, they are extensive and supplemented by carefully designed procedures and practices.